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USER GUIDE

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User Guide and Specifications for the Rehabilitation of Cold Water Copper Piping Systems

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USER GUIDE AND SPECIFICATIONS FOR THE REHABILITATION OF COLD WATER COPPER PIPING SYSTEMS

1 EXECUTIVE SUMMARY

Background

Copper potable water piping systems are generally expected to have a service life of 100 years with minimal maintenance requirements. In practice, however, some copper piping systems fail much sooner. Corrosion resulting from poor workmanship in the assembly of the system, specifically the excessive use of aggressive soldering flux, has been found to cause such failures. This problem is documented in cold water piping systems, but not in hot water systems because hot water tends to flush out the elements responsible for the corrosion. The U.S. Army Construction Engineering Research Laboratories (USACERL) has developed a technology that involves flushing the affected system with water of high temperature and velocity to remove excess soldering flux. Studies have shown that this rehabilitation of cold water systems significantly reduces the number of failures caused by flux-induced corrosion, thus reducing the expense of maintenance and replacement.

This technique is ideal for use in the field in systems affected by poor workmanship resulting from use of excessive solder flux since it is relatively simple and nonintrusive; it does not require the removal of any piping or destruction of any walls or floors. This technique is also environmentally acceptable, as it does not require the use of chemicals.

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2 PRE-ACQUISITION

Description of Technology

Unfortunately, workmanship problems associated with failures of copper tubes and fittings are usually not detected until after the system fails. Often the problem involves the excessive use of soldering fluxes. Copper is naturally protected from corrosion by a thin film of copper oxide, but activating agents in the flux can prevent the formation of this layer, making the copper more susceptible to corrosive attack. Since the water itself in hot water systems eventually flushes away the excess flux, a technique was developed to flush cold water systems with hot water at a high velocity for a relatively short period of time to remove any excess soldering flux residue left in the system.

Laboratory tests determined the optimum operating parameters for water temperature, velocity, and flushing time. Flow rate and temperature should be at or above 7.0 ft/s at 160 °F.* The piping system should be flushed for at least 3 hours (longer if time and facilities permit). A trailer mounted, self-contained, portable hot water generator was constructed to provide the water flow and temperature needed for the flushing technique. The hot water is supplied to the affected systems by a 1.25-in. diameter high pressure hose, which enters the generator in a 2.5-in. diameter hose originating from an available fire hydrant.

This system was successfully field tested at Fort Stewart, GA in November 1989. In August 1991, USACERL and its contractor returned to Fort Stewart, GA to verify long-term effects of hot water flushing. The investigation concluded that: (1) localized, soldering flux-induced corrosion had occurred on the waterside surfaces of all five specimens; (2) there had been poor workmanship when the copper tube systems were originally installed, and (3) the hot water flushing and subsequent flow of water effectively removed aggressive species from the solder on the waterside surface of the specimens.

If the copper tubing leaks and excessive solder flux is visible, a water sample should be taken from the cold water system and a similar hot water system to determine the chloride ion concentration. A higher amount of aggressive chloride ions in the cold water system than in the hot water system indicates the occurrence of solder flux-induced corrosion. Once identified, this corrosion process can be mitigated by the hot water flushing technique.

Life Cycle Costs and Benefits

This technology can reduce the amount spent on flux-induced, corrosion-related repairs of copper piping systems. At Fort Stewart, GA, approximately $240,000 annually was spent on flux-induced leaks (given a recorded leak repair rate of 100 per month). After the design and initial purchase of the flushing equipment at $20,000, the cost per building (including labor, fuel, and water) was $160 to perform the rehabilitation technique. This case involved two housing units that were being flushed at the same time. A conservative estimate is that the flushing of cold water systems like that at Fort Stewart will reduce

*1 in. = 25.4 mm; 1 ft = 0.305 m; 1 gal = 3.78 L.

leaks by 50 percent, cutting in half the money spent on maintenance of the systems. In other words, first year savings at Fort Stewart—including equipment design and purchase costs—would exceed $99,000:

Gross (estimated) savings 0.5 × $240,000	=	$120,000
Equipment design and purchase cost	=	– 20,000
Labor, fuel, and water costs (2 × $160)	=	– 320
Net (first year) savings		$99,680

3 ACQUISITION/PROCUREMENT

Potential Funding Sources

U.S. Army installations can use the Maintenance and Repair "K" account funds to procure the copper pipe rehabilitation system or any associated components.

Technologies Components and Sources

Each installation requiring the technology will be responsible for the acquisition and assembly of the components necessary for a flushing system. Installations can locate the appropriate parts required by using resources and information gained from the Savannah District demonstration. The essential parts and suppliers used by the personnel at Fort Stewart included:

Georgia Electric Supply Co. 19 Westgate Blvd. Savannah, GA 31405 ph. 912/234-2231	1. Circle F, Model 3635 male plug 2. Safety Switch, 2 Pole, 250 V, Fusible with fuses, weatherproof.
Hughes Supply c/o Peacock Sales P.O. Box 1647 Savannah, GA 34102 ph. 912/232-2226	1. TACO CM1207 Pump with 49-in. impeller, 3 hp, 1-phase, 240 V, 3500 RPM motor, capable of handling 160 °F hot water.
Wheel and Break Inc. ATTN: Mr. McBurnett Repair Shop 2647 Moreland Ave., SE Atlanta, GA 30315 ph. 404/624-1241	1. 100-gal fuel storage tank, steel, rectangular 42 in. long X 26 in. deep, part #2837.
Columbia Boiler Co. Box G Pottstown, PA 19464 ph. 213/323-2700	1. Model CWH-1510, #2 diesel fired w/ 100 °F rise @ 25 gpm continuous or equal.

A trailer needs to be procured as well. Fort Stewart used a 6 x 16 ft. utility-type trailer with rails and a gate.

Alternatively, the existing demonstration system may be acquired on loan from Fort Stewart, GA. For availability information contact Mr. Donald Thomas at 912/767-4794.

Procurement Documents

USACERL Draft Technical Report, *Demonstration of a Field Rehabilitation Technique for Removing Corrosive Solder Flux in Cold Water Copper Piping Systems* (due for distribution in FY94) evaluates the technique for mitigating solder flux-induced corrosion at the Fort Stewart, GA demonstration site, and is useful for comparing results between a given installation and those of the demonstration site. A Public

Works Technical Bulletin (PWTB) describing the in-situ technique for the removal of solder flux in cold water copper piping systems will be published by USACPW.

For averting solder flux induced corrosion, the Corps of Engineers Guide Specifications 15400, *Plumbing General*, and 15405, *Plumbing Hospital*, should be followed when designing and installing building copper piping for potable water and process water usage.

1.0 Designs

The flushing system is to be assembled by the Directorate of Engineering and Housing/Directorate of Public Works (DEH/DPW) personnel at the appropriate installations. Several generalized plan drawings are mentioned below.

Figure 1 shows a schematic of the trailer setup used at Fort Stewart. A similar trailer could be used in the same configuration. Ensure that loads are distributed on the trailer to keep most of the weight over the axles and to the front of the trailer to avoid potential safety problems.

Figure 2 shows a piping schematic for a boiler system as specified by Columbia Boiler Company. Temperature and pressure measurement devices should be added before the entrance to the heater and beyond the pump exit to permit monitoring for acceptable water conditions.

Figure 3 shows an expanded schematic of the electrical connections for the installation of the pump switch.

Specifications

Portable Water Heater

The hot water generator shall be a Columbia model TWH-WL120, #2 diesel-fired, 40 hp, with 100 °F rise/constant draw at 25 gpm (equal to 1510 gph), and a watertube, water-leg design. The boiler shall be a forced draft, pressure-filled, steel boiler, S.B.I. approved and constructed in accordance with requirements of Section IV of the ASME Boiler and Pressure Vessel Code:

1. Performance Ratings for TWH-WL120:

a. Input:	12.00 gal/hr
b. Horse power:	40
c. Water capacity:	193 gal
d. Tankless water heater size No.:	10F
e. Tankless water heater connections:	1 in.
f. No. of tankless water heaters:	2
g. Mixing valve size:	2 in.

2. Continuous Draw Outputs:

a. Gal per minute 80 °F. Rise:	31
b. Gal per minute 100 °F. Rise:	25
c. Gal per hour 80 °F. Rise:	1890
d. Gal per hour 100 °F. Rise:	1510

3. Standard Water Heater Trim for TWH-WL series:

a. Steam gage	0 to 30 psi
b. 12-in. Water gage set	
c. McDonnell & Miller #767 low water cut-off	
d. Safety valve: TWH-WL 120:	15 psi-con. valve, 1-1/2-in. M x 2-in. F, #13-214, 1900 lb/hr
e. SBI water treatment compound TWH-WL 120:	five 16 oz. bottles
f. L404A Pressure control	2-15 PSI,
g. Operating aquastat	L4006A,
h. High limit aquastat	L4006A,
i. Manual	

The diesel unit includes an oil burner with cad cell control.

Circulating Pump

The circulating pump shall be a TACO CM1207 pump with 4.9-in. impeller; 1 phase, 240 V, 3450 RPM, 3 hp motor; capable of handling 160 °F hot water.

Connections and Hoses

Supply water from a fire hydrant to the water generator shall be conveyed with a 2-½ in. diameter fire hose. Flush water delivered from the water generator to the housing unit shall be conveyed with a 1-¼ high pressure hose. The connection to each housing unit shall consist of a line size copper tee and shoulderless coupling. The tee shall be provided with a female thread on the outlet. Only ASTM B-32, 95-5 tin-antimony solder shall be used.

Procurement Scheduling

The lead time required for implementing the technology depends on the availability of the parts required to assemble the flushing system. The appropriate fire safety authorities should be notified early in the procurement process to request authorization to use the needed fire hydrants.

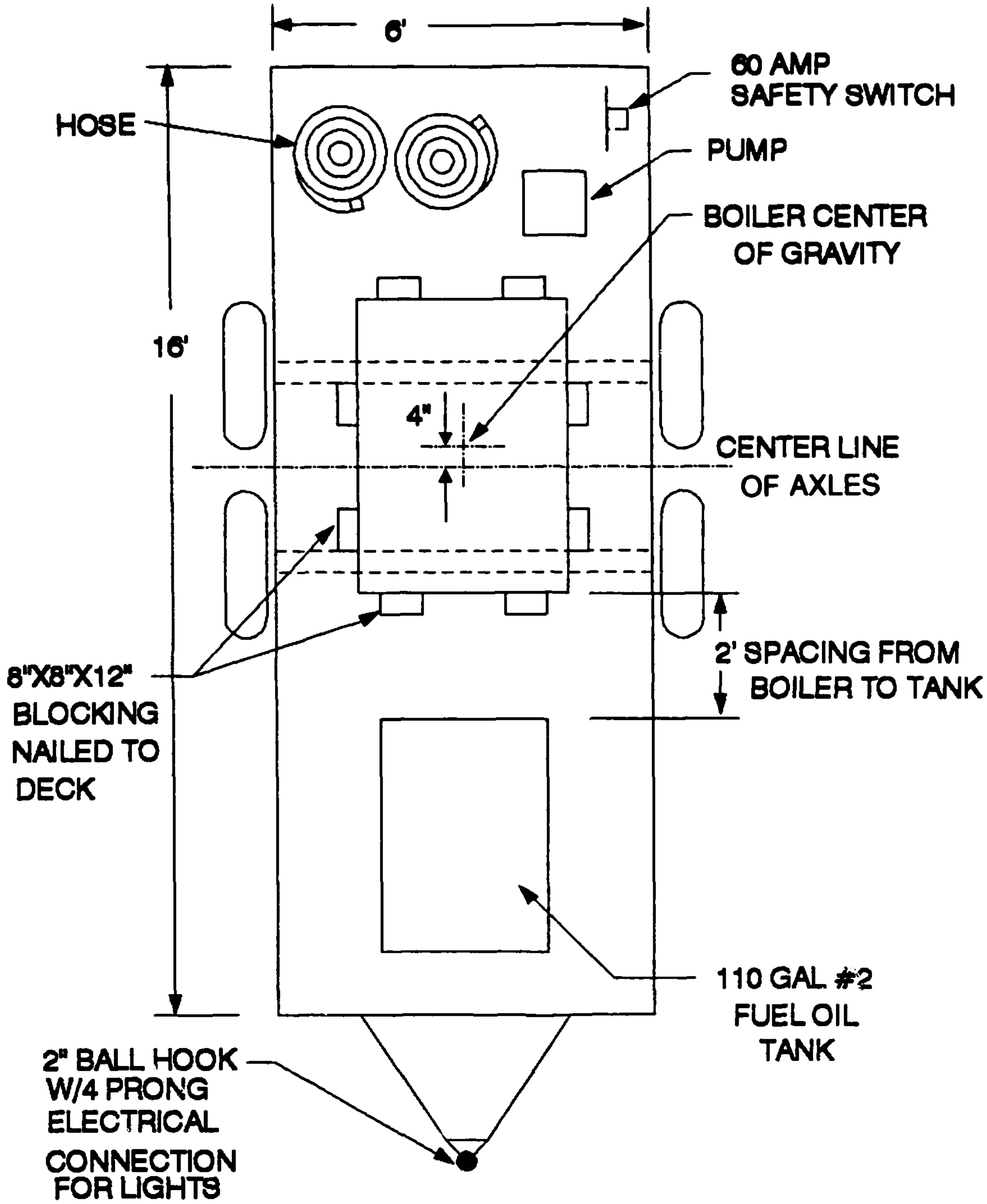


Figure 1. Trailer Set-Up.

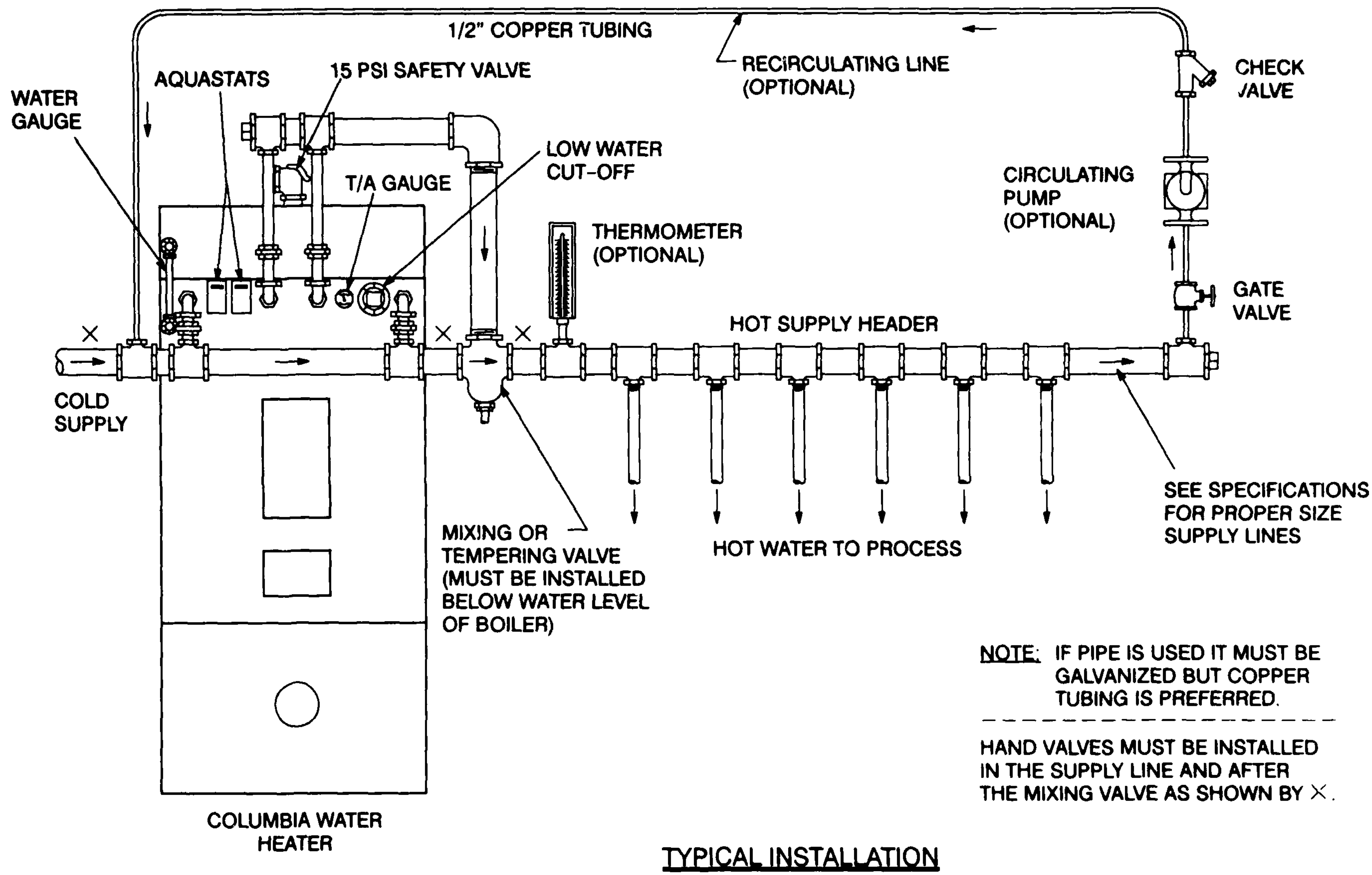
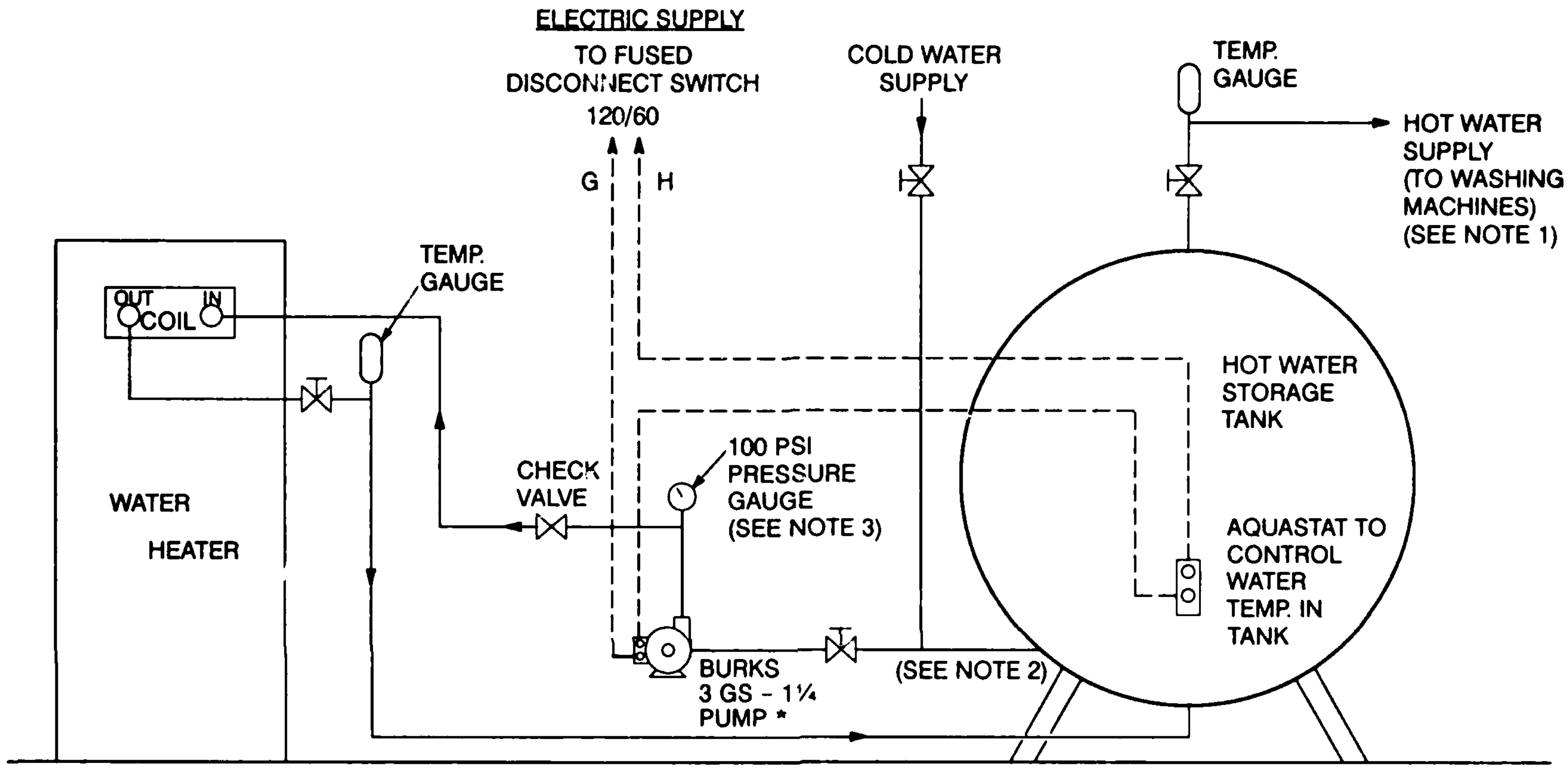


Figure 2. Manufacturer-Specified Boiler Configuration.



NOTES:
1. HOT WATER SUPPLY OUTLET SHOULD BE AT TOP OF TANK AT AQUASTAT END.
2. COLD WATER SUPPLY INLET SHOULD BE AT BOTTOM OF TANK OPPOSITE AQUASTAT END.
3. INCREASING PRESSURE ON THIS GAUGE WHILE PUMP IS RUNNING INDICATES SCALE BUILD-UP IN COIL OR OTHER RESTRICTIONS IN CIRCULATING LOOP.

* OR EQUIVALENT - - DO NOT USE RESIDENTIAL TYPE CIRCULATING PUMP

Figure 3. Pump Switch Electrical Connections.

4 POST-ACQUISITION

Initial Implementation

The work consists of:

1. Confirmation of fire hydrant access authorization.

2. Installing a purge water connection tee in the cold water line of each unit at the main source for each unit.

3. Connecting water lines from the portable boiler to the new tee in the domestic water system, powering up the boiler, and pumping 160 °F hot water at 7.0 ft/s through the cold water systems for 3 hours on each unit with faucets open to flush out the system.

Operation and Maintenance of Technology

The following procedure for the flushing of affected cold water systems was developed as a result of lessons learned from the Fort Lewis site demonstration. Not all sites using the technology will encounter identical flow rates, pipe sizes, head losses, etc. The water flushing velocity can be measured by a commercially available instrument such as an ultrasonic flow meter, which measures velocity externally through the pipe wall. If the desired velocity of 7.0 ft/s cannot be achieved because of the system's size, the next best option is to flush smaller sections of water lines. For example, the lines running to each bathroom could be flushed separately, or the house water system could be flushed section by section. If the system is to be flushed by sections, the job should be done systematically to ensure that all of the lines are flushed. The installation's chief of engineering is responsible for isolating the appropriate flushing system in which the velocity requirements can be met.

Specifications for the connection and tubing to be installed:

> A new line size tee and shoulderless coupling shall be installed in the water service line to each unit to be serviced. The tee shall be provided with a female thread on the outlet. The tee and shoulderless coupling shall be located between the housing unit shut-off valve and the pipe entrance. For those units where the service line enters through a riser in the outside utility closet, the new tee/coupler may be installed in this location. Others shall be located outdoors. Location of the tee/coupler shall be coordinated with the DEH family housing representative. Note: Only ASTM B-32, 95-5 tin-antimony solder shall be used.

Operating procedures for the technology:

1. Park the trailer/boiler in a level position, further leveling the trailer as needed, close enough to a set of housing units to reach the utilities.

2. Remove all aerators from the faucets present in the unit.

3. Turn off the service water supply to the housing unit.

4. Turn off the supply valve to the hot water system.

5. Open all cold water taps, one hot water tap, and the outside hose bib. Prop open the flush valve in each water closet to allow continuous flow. Disconnect the cold water line to the washing machines and run them to a drain.

6. Connect the boiler input water hose to the nearest fire hydrant, and connect the boiler hot water hose to the newly installed tee. Connect the trailer mounted pump's electrical extension cord to the nearest 240V power source outlet with the safety switch for the pump in the off position.

7. Open the fire hydrant to purge the system of air, then turn on the water pump at the trailer. Fire up the boiler and let the temperature rise.

8. Once the 160 °F temperature has been reached, continue to run hot water through the system for 3 hours while maintaining at least 7.0 ft/s flow in all sections.

9. Ensure that the water supply to the boiler is not interrupted during the operation.

10. After the flushing operation is complete, shut off the boiler but let the water continue to run until the temperature returns close to normal, turn the pump off, then shut off the "hot water line" leaving the boiler. DO NOT SHUT OFF THE SUPPLY LINE TO THE BOILER. Disconnect the hot water hose and move on to the next unit (assuming the next unit to be serviced is near the first).

Cleanup and restoration to normal:

11. Follow the above steps, 1 through 7, in reverse order to restore the water system to normal. The operators will be responsible for cleaning any incidental soiling of the floors or carpeted areas due to foot traffic.

12. The tee installed in the supply water line will be left in place and plugged with a threaded copper plug.

13. After each flushing operation, the housing unit water supply will be returned to normal.

14. Pressure test. A pressure test will be performed immediately following the flushing. This can be done at the same time as the cleanout work for the next housing unit to be flushed. Attach a 0 to 100 PSIG gage to the outside hose bib. Purge air, fill, and pressurize the housing unit water piping by opening the cold water service valve. Close the service valve and record the pressure reading. After 1 hour, record the new pressure reading, remove the gage, and restore cold water service if no leaks are detected. Report pressure readings to the Contracting Officer's representative, along with any possible problems detected.

15. If leaks are detected, turn off the water supply at the main service valve and report the problem to the Contracting Officer's representative.

16. Secure the unit, and return the keys to the contracting officer.

The operators will not be held liable for water damage or leaks that develop from the flushing process provided all normal precautions are used to ensure that the drains are open. The operators will not be held responsible for repairs on the portable boiler, provided normal manufacturer's recommended operating procedures are followed.

Service/Support Requirements

The flushing of cold water systems does not require any specialized labor, except for the coordination with fire safety officials for use of the fire hydrants. The flushing can be performed by in-house labor. Various manufacturers should be able to assist with the implementation and maintenance of the individual components of the copper piping rehabilitation system. The U.S. Army Construction Engineering Research Laboratories will also provide technical support during the implementation process.

Performance Monitoring

After the flushing process, water samples should be taken to determine the chloride ion concentration still remaining in the cold water system. The post-flushing concentration should be no greater than that of the hot water system.

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